Art. IX.—*Surface Tension as an Aid in Canyon Formation, the production of Bad Lands, and in River Capture.*

By J. A. LEACH, M.Sc.

(With Plate XVII).

[Read 13th December, 1906].

Being attracted by a statement made by Professor Miall that the surface film of water was a veritable death-trap to many small animals, my thoughts turned much to phenomena connected with that remarkable film.

This statement was soon seen to be true, mosquitos, water-fleas (Daphnia), and many small pond animals have been seen held close prisoners by this wonderful "top of the water." Other animals, such as mosquito larvae and pupae, pond snails, hydra, etc., were seen, however, to take advantage of it.

It is well known that soap bubbles are due to this phenomenon, while the sphericity of rain-drops is also caused by its action. The necessity of droppers for medicine, of lips and spouts for jugs, teapots, and other vessels is also due to the tendency of this surface film to adhere to any body it might happen to wet. This tendency to adhere instead of falling vertically downward is, I hope to show, a most important factor in the denudation of the earth's surface, especially in canyon production, by causing rapid undercutting where there are softer beds.

A hard surface layer covering softer rock will present conditions favourable to the formation of a waterfall. The water rushes over the hard ledge, and falls to the earth beneath. The swirl and the splash soon wear out a circular hole—a pot hole. If the ledge is of some height, the water leaps over. The spray is splashed around and the softer material under the ledge is worn out. Sooner or later, the surface ledge breaks off and falls in. Thus the canyon or gorge travels up stream.

This is the explanation usually given, and probably it is correct in most cases. However, at Coburg one day, when examining the head of some "bad lands" with canyons nearly 20 feet deep, this explanation was seen to be unsatisfactory for three reasons.

1. The quantity of water that was doing the wearing out was very small. It was only the small amount that flowed from a few square yards of a uniformly sloping hillside, for there was no stream, not even a gutter or runnel. It was too small a quantity to splash about.

2. This small amount of water could not have splashed high enough to wash the softer subsoil from just below the surface crust (a hard band several inches thick), which was at the height of eleven feet (Fig. 2).

3. There was no evidence of any fall of water at all. If a fall took place from that height, there would be a pot hole at the foot of the fall, or stones showing some signs of water splashing or falling. But there was no trace of this.

The usual explanation clearly did not account for the wearing out, and the evident recent advance up hill of this gorge. As no water was then running over, no other explanation presented itself at the time.

Shortly afterwards when at Heidelberg, the usual hollow was noticed under the surface crust; but it did not reach down to the bottom. The crust was six inches thick. Then a semicircular hollow about ten inches in diameter led to a gently sloping piece of about fifteen inches down to the bottom (Fig. 4.) Here, as no sign of any falling water could be seen on the sloping base, there was obviously no splash at all. Thus the water did not fall over. Close examination showed that the water trickled down the surface crust and then adhered underneath it, the water surface forming the outer wall of a kind of a pipe. The water then ran down, following under the surface crust, over the soft material underneath, and so trickled this down as liquid mud. Thus the earth was hollowed out right under the crust, but it had not yet been worn away down to the level of the bottom. Many little grooves could be plainly seen where the water had trickled down, and carried off the material.

A visit shortly after this to the Royal Park railway cutting showed where the water had trickled over the edge of a hard ironstone layer. It had carried down the sand and clay mixture under it. Some of this liquid mud had then fallen a short distance from a convenient hard point. Here it had built up two little mud pillars (stalagmites?) of the deposits from the liquid mud which had trickled down.

In all the railway cuttings in the coastal plain material round Melbourne, this scooping out of the softer material under the harder bands can be clearly seen. That also is one of the features so noticeable in many of the good views of the Grand Canyon of the Colorado.

In each of the numerous cases of canyon formation now going on around Melbourne that I have visited, the same phenomena have been noticed. In a few cases, even where wearing away is proceeding very rapidly, no water falls over. All the water causing such serious loss to the land owners simply trickles down over the softer material. This, when wet, becomes liquid mud. So the solid earth is really melting or flowing away.

In one case at North Essendon a brick wall, with a large V opening for the water to flow in, was built across a gutter leading from a road to the adjacent Moonee Ponds Creek. This rejuvenated stream had deepened its bed over 20 feet. The trickle of water from the gutter soon wore the soft alluvium away, and formed a deep canyon.

The water then worked under the brick wall, which has now been left high and dry across a considerable canyon, with the water flowing many feet below the lower portion of the brickwork. This alarming result has been accomplished in a very short time by the very small quantity of water that flows, only after rain, in a gutter at the side of the road.

The harder Silurian bedrock, of course, would not be worn away so readily, so that it is only in the softer material of the coastal plain, or other recent deposits, that this very rapid weathering is going on. Still, it is being done by an insignificant quantity of water.

In the canyons at Coburg, the side of the gorge is coated with a very fine powdery material. This has been left there when the water, which in wet weather formed a film over it,

evaporated. It is material which was in mechanical suspension, being carried down and acting in its turn as a file to wear away still more of the loosely cemented hill-side.

Even where there is water falling over into the canyon, some of it always trickles down adhering to the surface. It then quietly trickles out any softer band. Surface tension, therefore, greatly helps the splash in the wearing under by a waterfall.

In canyon formation, especially in the advance of the main canyon upstream and in the lateral widening of the canyon, surface tension is seen to be an agent of the first importance by enabling the water to adhere to the rock. This water thus runs over the softer bands, otherwise protected from water action. These are quickly worn out and removed. The harder beds being unsupported, now break off and fall in, and so the canyons grows. Thus the undercutting can in many cases be said to be directly due to the effect of the surface film of water.

A recent visit to the Coburg bad lands, east of Pentridge, showed many canyons, varying in depth up to nearly 20 feet. In not one single case could any trace be discovered of a splash at the bottom of the fall at the head of any of the several canyons.

As a teacher, difficulties have been experienced in leading a class to understand how on a slope, say N. and S., a lateral tributary might cut across this slope from E. to W., and the streams flowing on it be captured and diverted. There is some reason for believing some of the present rivers have so cut across the old southerly flowing rivers of Central Victoria.

To illustrate this an excursion was undertaken to Kilby Lagoon, near Kew. Here on the hillside is a canyon with several lateral tributaries. These carry but little water—just a trickle after rain in fact—yet the softer material has been quickly trickled down until now a lateral tributary, flowing entirely underground (for the surface crust, supported by the thick mat of grass roots, has not yet fallen in), drains much of that hillside, though it is sloping north, out to the west.

This wearing-out has been accomplished in a very short space of time, for the hillside has been ploughed, as the old furrows plainly show.

Thus surface tension, acting indirectly, is seen to be an agent in river capture by quietly but surely working a side tributary

gorge back across other streams. The original streams are beheaded, and their waters diverted into the subsequent streams.

There has been a considerable boom in surface tension. It has been called in to explain, or at least to be held in some way responsible for, many divergent phenomena. The geologist, so far, has not claimed much from it, but here we can see it is proving a remarkably efficient aid in the rapid denudation of parts of the earth's surface.

In many parts of Victoria, even away from the coast, where there has been possibly a recent uplift to rejuvenate the streams, canyons are being formed. On the gold-fields the softer alluvial drifts also are being rapidly worn into canyons and bad lands.

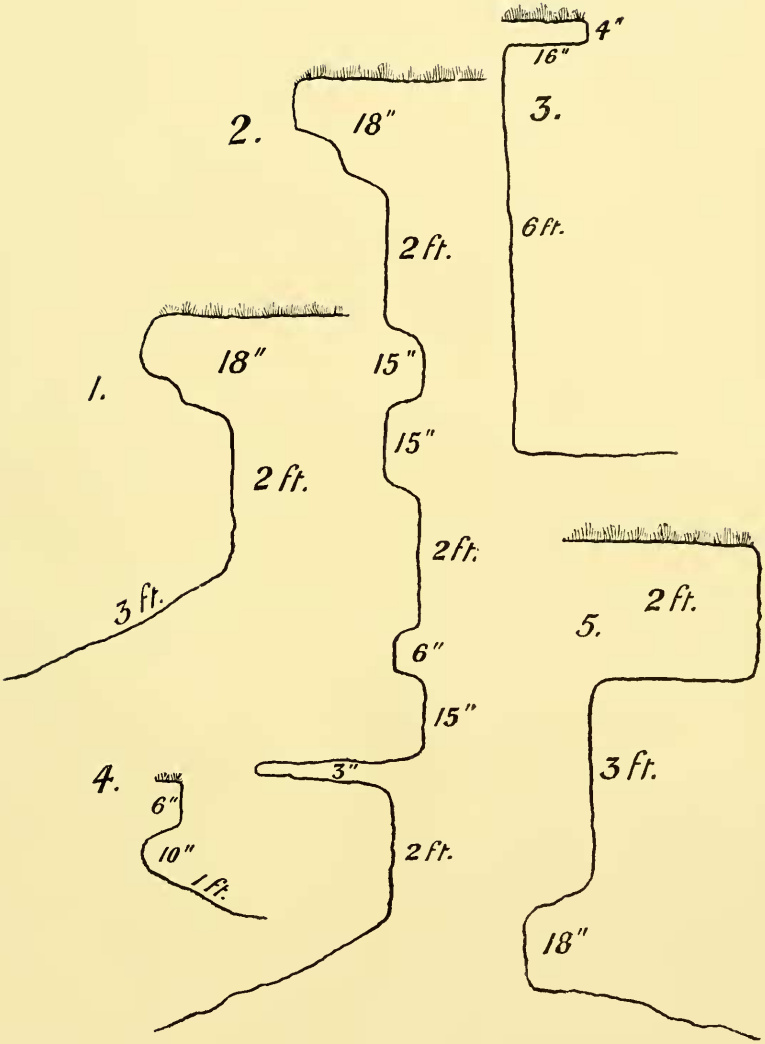
In conclusion, we have seen that in at least three ways surface tension is an important aid in denudation by enabling water to adhere to an undercut face.

1. Even where there is a waterfall, with its consequent splash, some water at least trickles down, adhering to the face throughout. By this means soft beds are trickled out. The harder bands, being unsupported, then break off.

2. Where there is not a permanent stream, surface tension is a most important agent (especially if there is only a small quantity of water), in assisting in the wearing-back of the head of a gorge. It is also of great importance in widening out a canyon and in the formation of tributary gorges and bad lands.

3. It is an important agent in river-capture by enabling a small quantity of water to attack the softer underlying layers, and so remove them. Thus it cuts back and across other streams.

It is to be distinctly understood that the general question of denudation and denuding agents is not discussed here. The point is the importance of the surface film as an agent in undercutting, as opposed to the splash from a waterfall. Thus the surface film becomes an aid in corrosion and erosion.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